

# Short Baseline Neutrino Workshop



Future Detector 2 ■

## Short-Baseline Neutrino Workshop

12-14 May 2011

Detector 1 ■

### Fermilab

Neutrino Source ■

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*The workshop will cover recent short-baseline neutrino results, theoretical interpretations, future neutrino facilities, and future short baseline neutrino experiments. The goal of the workshop will be to discuss future facilities and experiments that can be built at Fermilab and elsewhere to explore short-baseline neutrino physics (including neutrino oscillations, CP violation, sterile neutrinos, axion searches, cross sections, etc.).*

<https://indico.fnal.gov/event/sbnw2011>

*Supported by Fermi National Accelerator Laboratory and Los Alamos National Laboratory*

Richard Van de Water (LANL)  
SBNW11, May 12-14, 2011

# WorkShop Summary:

- Acknowledgments
- Overall impression of the workshop
- Brief summary and key questions
- Requirements for future beam experiments
- Future experiments/facilities
  - Short term
  - Mid term
  - Long term
- Questions to motivate discussion

# Thanks to...

- You, for coming out and making this conference a success!
- FNAL and LANL for supporting the conference.
- The scientific and local organizing committee for a great selection of talks.
- Zarko Pavlovic and Ellen Klein for creating and maintaining the web site.
- And especially Elaine Philips and the FNAL conference staff who helped organize and run everything smoothly!

# Overall Impressions...

- Great turnout  $> 100$  participants.
- Lots of interesting and new ideas.
- Drawing connections between different experimental results and theoretical explanations.
- Lively and informative discussions.
- Overall, I think this was a successful conference and achieved the goal of getting the community together and to begin thinking seriously about  $L/E \sim 1$  physics.

# Good One Page Summary...

## Evidence(?) For Physics Beyond the Three-Massive-Neutrinos Paradigm

- LSND  $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ ;
- MiniBooNE  $\nu_\mu \rightarrow \nu_e$ ;
- MiniBooNE  $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ ;
- Reactor Anomaly;
- MINOS  $\nu_\mu$  versus  $\bar{\nu}_\mu$  oscillations;
- Ga Anomaly;
- ? BNL E734

## (Some) Phenomenological Explanations

- Sterile Neutrinos (light, stable variety); LSND, MB, Reactor, Ga, solar
- New Neutrino Interactions; MINOS, solar
- Lorentz Invariance/CPT-Violation; “all”
- Sterile Neutrinos (heavy, unstable variety). LSND, MB

## Plus

- Where is the “up-turn” in  $P_{ee}$  for low-energy solar neutrinos?

# My broadbrush view:

- There are a smorgasbord of experimental hints that point to possible new physics.
  - “Not a single piece of evidence that directly contradicts LSND/Miniboone”.
  - Much circumstantial experimental evidence that supports LSND/MB from MeV to GeV range. Karmen and numu disappearance provides some restriction.
- There are a number of interesting theoretical ideas that could explain some or all the experimental results.
- The question now is where do we go from here???

# Some key questions/observations:

- Need to make smoking gun measurement.
  - How do we do it quickly?
  - Numu or Numu-bar disappearance??
- Need to make a  $>5$  sigma measurement at  $L/E \sim 1$  to convince the community.
- Not sure of underlying physics, so need a experiment with diverse capabilities that can test many ideas.
  - Will probably be costly.
  - Or, try many smaller/cheaper/quicker experiments that excel at testing certain models.
- Cross sections effects are important, and can change interpretation of oscillation results.

# Requirements for next beamline experiments:

Need to measure neutrino properties to the ~percent level.

Rate = Flux x Cross Section x detector response

Flux: Intense source  $\rightarrow$  Booster/MI, CERN-PS, SNS, cyclotrons, LBNE, Project X. Measure flux insitu using H/D<sub>2</sub> targets.

Cross Section: Need better models, especially to measure correct neutrino energy. Much data on Carbon, need more data for Ar.

Detector Response: LAr would allow separation of electrons and gamma-rays. Want good tracking and magnetic fields. 2 detectors or long detector to measure L/E effects.

# Near Term Goals (~few years)

## Search for smoking gun:

- Keep running MB to improve antinu statistics (collect  $\sim 1.1 \text{E}21$  POT).
- Finnish SB/MB numu-bar disappearance.
- Oscillation updates from Minos (antineu NC, LV).
- Analyze IceCube data, look for numu-bar disappearance.
- Make more cross section measurements with Minerva, Minos, MB, ArgoNeut.
- Develop better cross section models.
  - > Apply to recent oscillation results, e.g. could it explain the difference in MB nue/antineu appearance result?

# Mid Term Possibilities (3-7 years)

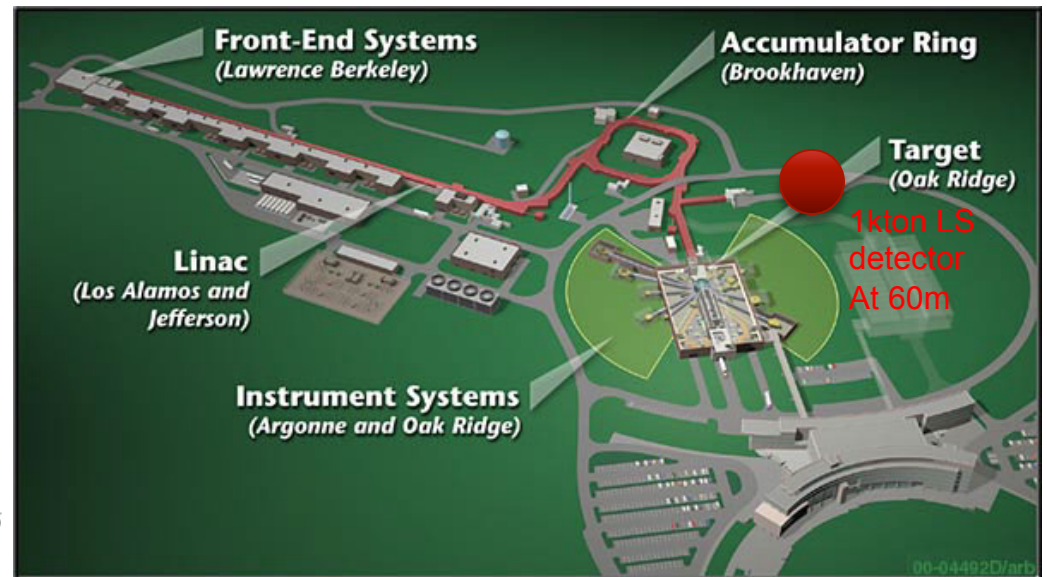
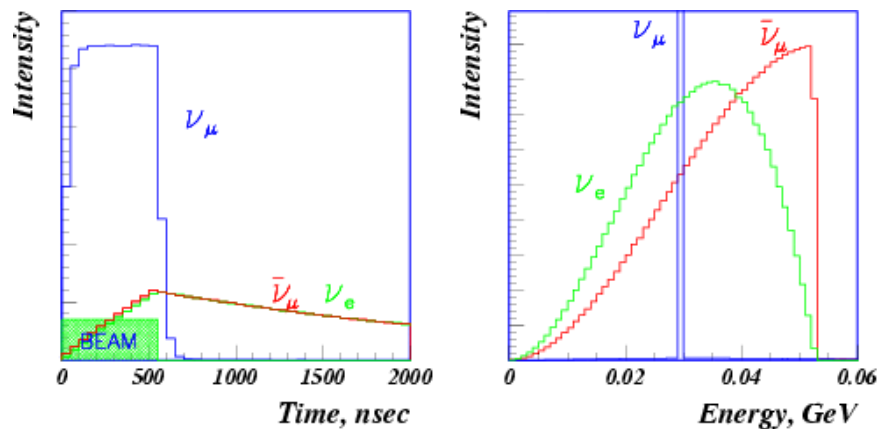
## Make Detailed measurements to begin understanding the underlying physics:

- Run uBooNE to test MB low energy anomaly.
- Build BooNE (near detector) – decisive ( $\sim 5$  sigma), quick, inexpensive, on Carbon (measure disappearance/appearance).
- Build OscSNS/cyclotron experiment (stop pion source) to retest LSND directly  $> 5$  sigma.
- Minos+ running to search for sterile  $\nu$ , NSI, etc.
- Build and run 2 LAr detector experiments at CERN and FNAL to make definitive test of appearance, disappearance,  $\nu$  decay, LV, etc.
- Katrin results.
- NOvA (2<sup>nd</sup> near detector) and SciNova.
- Develop Muon Storage ring, Reactor (SCRAAM) and Source (LENS, Ga, Borexino) experiments.

Improve the odds...

# **SuperSearches for SuperSterile Neutrinos with SUPERBooNE**

# OscSNS at ORNL: A Smoking Gun Measurement of Active-Sterile Neutrino Oscillations



**SNS:  $\sim 1$  GeV,  $\sim 1.4$  MW**

$\nu_\mu \rightarrow \nu_e$  ;  $\nu_e p \rightarrow e^+ n \Rightarrow$  re-measure LSND an order of magnitude better.

$\nu_\mu \rightarrow \nu_s$  ; **Monoenergetic  $\nu_\mu$**  ;  $\nu_\mu C \rightarrow \nu_\mu C^*(15.11) \Rightarrow$  search for sterile  $\nu$

OscSNS would be capable of making precision measurements of  $\nu_e$  appearance &  $\nu_\mu$  disappearance and proving, for example, the existence of sterile neutrinos! (see Phys. Rev. D72, 092001 (2005)). Flux shapes and cross sections are known very well.

# Long Term Possibilities (>8 years)

## Make Precision measurements of new physics:

- If smoking gun found, then design/build a series of experiments with Project X to explore in detail the source of new physics:
  - DIF (300–600kW at 3GeV, 25–50kW at 8GeV)
  - DAR (difficult)
  - Beam dump (exotics – axions, paraphotons, etc)
  - Cross sections
  - Flux measurements with H/D<sub>2</sub> targets
  - Other experiments?

# Important point!

- To help achieve the goals outlined in the last three slides, we need to work as a community to get into NSAC, P5, etc, long range plans.
  - >Important for securing funding opportunities

## Questions to motivate discussion:

1. Is there enough experimental evidence to pursue further investigation?
2. Do we understand enough about neutrino fluxes, cross sections, and backgrounds to be confident in the present oscillation results?
3.  $3+N$  sterile neutrinos seem to be preferred, how viable are other physics explanations, e.g. non standard interactions, neutrino decay, axions, LV, etc? How do we test for them?
4. What is the best neutrino experiment to pursue when one is not sure of the physics?
5. What is better; more powerful flux (project X), precision flux (stop pion source), reactors, sources, or all?
6. How many, and what type of experiments are necessary to span the possible physics explanations?
7. Do we need this conference on a yearly basis?